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COMPARISON OF A TWO-BURN SCHEME TO AN RCS INSERTION TECHNIQUE FOR LUNAR ASCENT

By William C. Lamey

Lunar Landing Branch

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PROJECT APOLLO

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Approved: Floyd V. Bennett
Floyd V. Bennett, Chief
Lunar Landing Branch

Approved: John P. Mayer
John P. Mayer, Chief
Mission Planning and Analysis Division

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COMPARISON OF A TWO-BURN SCHEME TO AN RCS INSERTION TECHNIQUE FOR LUNAR ASCENT

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SUMMARY

The performance of a two-burn scheme and the standard RCS insertion technique were compared to determine which scheme has the greatest capability for LM lunar orbit insertion. This comparison was made assuming a contingency situation prior to the powered ascent launch, which caused the APS available propellant to become critically limited.

Targeting for the two-burn scheme resulted in the standard 60 000-ft by 30 n. mi. orbit after completion of the second burn. The results of this study indicated that the two-burn insertion gives approximately 20 fps more ΔV capability than the RCS insertion technique.

INTRODUCTION

Prior to the LM powered ascent, it is possible that a leak could develop in the ascent propulsion system (APS) propellant tanks. A situation of this type or some other malfunction could cause a reduction in the characteristic velocity capability for the powered ascent. Furthermore, targeting the powered ascent to extremely low insertion orbit altitudes (such as 25 000-ft circular) results in only small characteristic velocity savings and would make LM rescue very difficult. If a malfunction does occur that would affect the characteristic velocity capability of the powered ascent, a scheme for orbit insertion in such propellant critical situations is desired. This study describes a two-burn scheme for insertion into the standard orbit (60 000 ft by 30 n. mi.) and compares the performance of such a scheme to that of the standard RCS insertion technique.

DESCRIPTION OF INSERTION SCHEMES

Geometrical sketches of the two schemes are shown in figures 1 and 2. The first burn of the two-burn scheme (performed by the APS) is initiated on the lunar surface (fig. 1). It is targeted to various burnout velocities depending on the desired true anomaly at burnout. The resulting trajectory is an ellipse with a 60 000-ft apocynthion altitude. The APS burnout altitudes are always below 60 000 ft. The second burn occurs near apocynthion of the ellipse resulting from the first burn and is performed by the RCS. The resulting orbit of the second burn is the standard 60 000-ft by 30-n. mi. ellipse. Between burnout of the first burn and apocynthion of the intermediate ellipse the smallest central angle considered was approximately 8.0°.

The standard RCS insertion technique (fig. 2) uses the present PGNCS implementation whereby the maneuver is manually steered, from a computed display, along the velocity-to-be-gained vector, V_g (ref. 1). When using this technique, it is assumed that the propellant in the APS tanks is depleted at various times prior to orbit insertion and that the standard launch targeting is employed.

DISCUSSION OF RESULTS

Performance of the two schemes are compared to determine which scheme is more desirable if a propellant-critical situation occurs prior to launch. The amount of deliverable RCS propellant available for mission planning is 588 lb (ref. 2). After considering the propellant used for LM descent, mixture ratio uncertainty, and gaging accuracy, the amount of RCS propellant available at lift-off is approximately 350 lb. The RCS interconnect is assumed to be operative for this study.

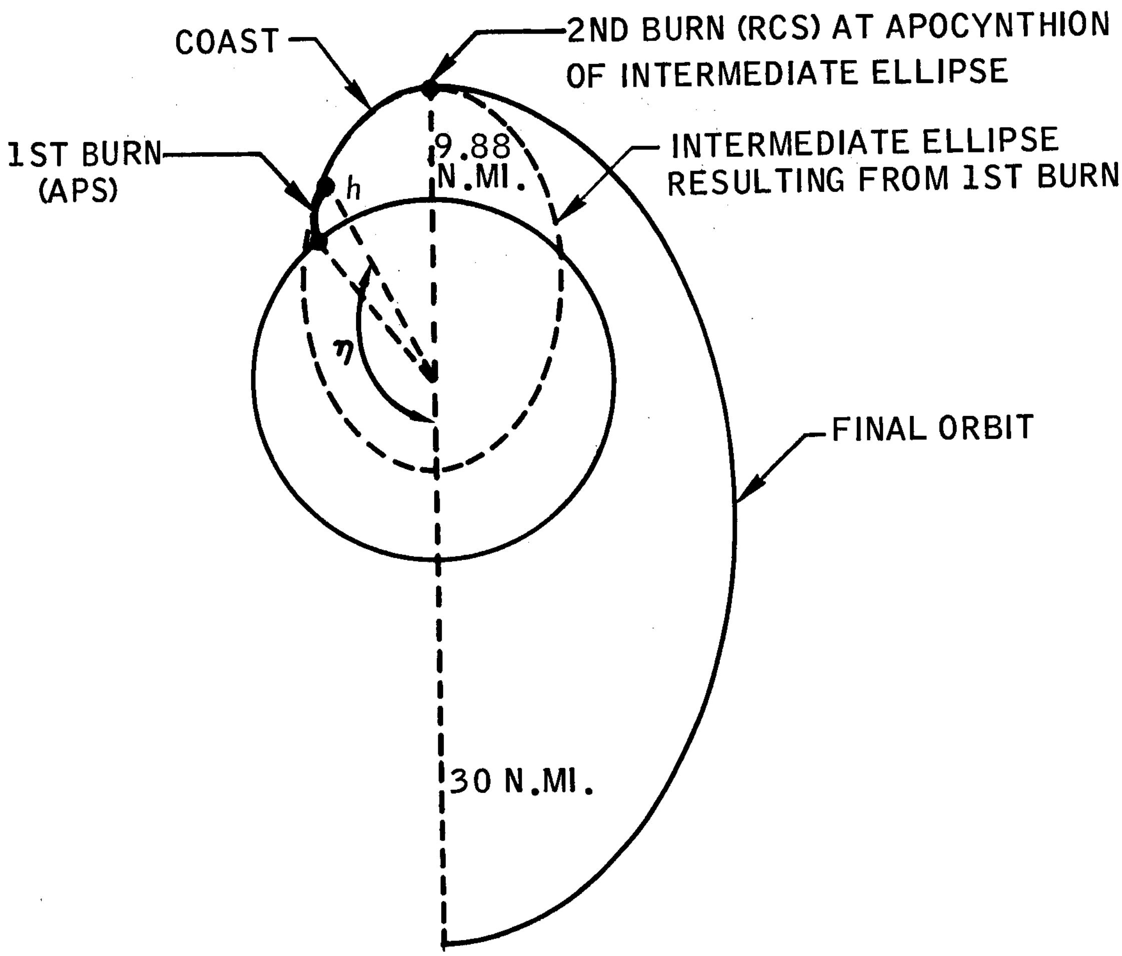
Insertion requirements (horizontal and radial velocity) for the two-burn scheme are shown in figure 3. Figure 4 shows characteristic velocity requirements for the two-burn insertion. Propellant requirements for the two-burn scheme are shown in figure 5. These two figures (5a and 5b) show that if a propellant-critical situation limits the useable APS propellant to approximately 4680 lb, with a corresponding characteristic velocity of approximately 5521 fps, the RCS would have to burn to propellant depletion to complete the desired insertion.

Characteristic velocity requirements for the RCS insertion technique are shown in figure 6. Figure 7 presents propellant requirements for the RCS insertion technique. The performance of this technique shows that the RCS would be required to burn to propellant depletion to obtain the desired insertion conditions if a propellant critical situation occurs approximately 27 sec prior to insertion. The amount of APS propellant used at this point into the ascent is a minimum of 4691 lb. The corresponding characteristic velocity for the APS burn is approximately 5541 fps. The insertion altitude profile for this technique is shown in figure 8.

This plot shows the insertion altitude as a function of the time of APS tanks propellant depletion.

CONCLUDING REMARKS

An investigation of two possible insertion schemes assuming a propellant-critical situation prior to the powered ascent launch has been presented. Performance of the two schemes (the two-burn scheme and the standard RCS insertion technique) were compared to determine which had the greatest insertion capability. The performance capability of each insertion scheme was based on the assumption that the available RCS propellant at lift-off was 350 lb. The results of the study indicated that the two-burn scheme has an insertion ΔV capability of approximately 20 fps more than that of the RCS insertion technique.



η = TRUE ANOMALY AT BURNOUT (BURN NO. 1)

h = INSERTION ALTITUDE (BURN NO. 1)

Figure 1.- Scheme for two-burn insertion at pericynthion into a 60 000-foot by 30-nautical mile orbit.

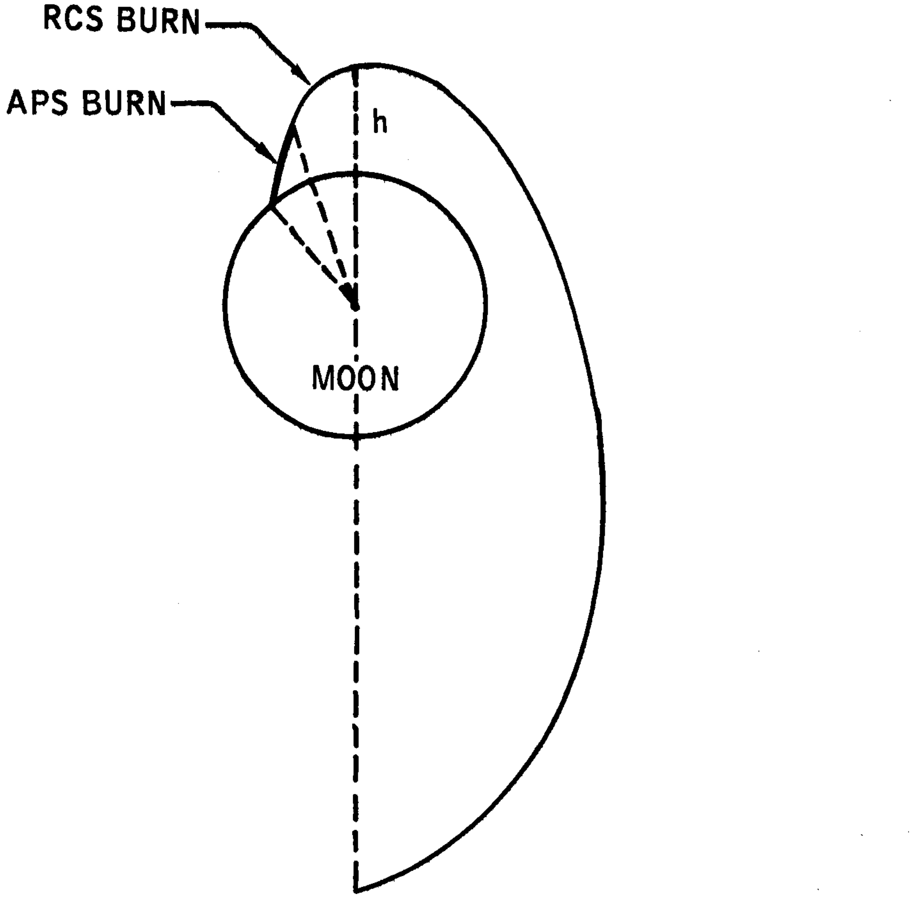
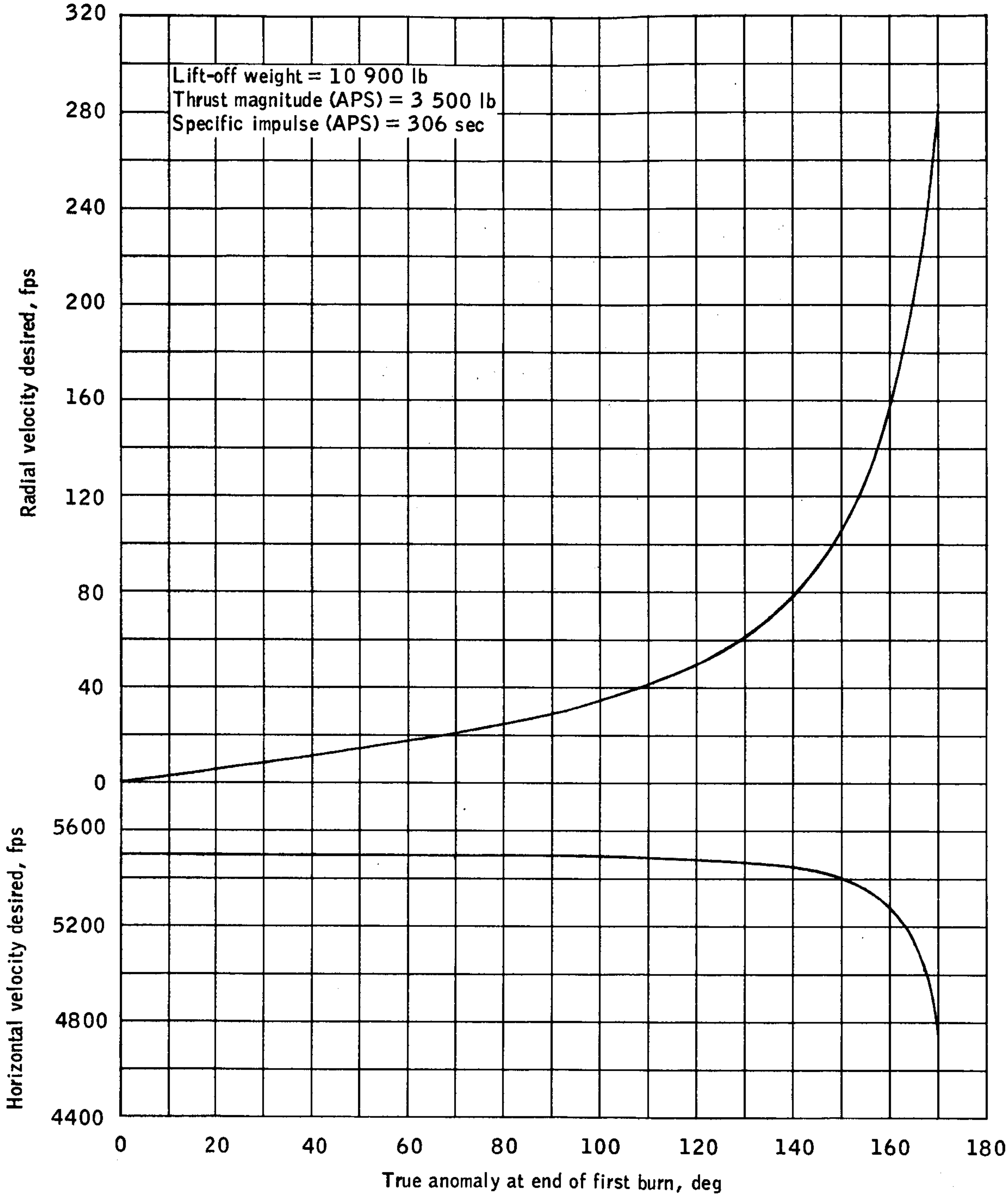
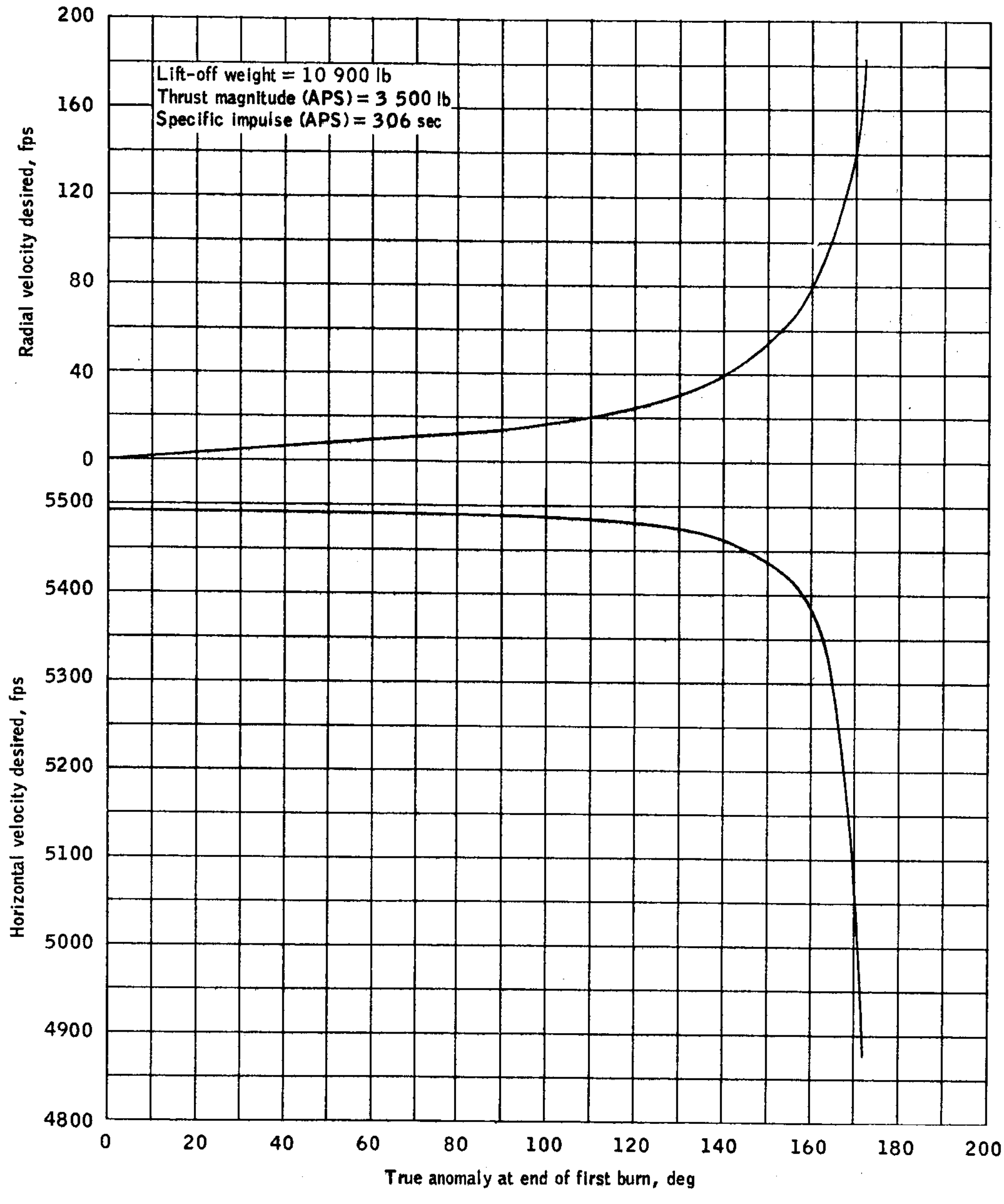


Figure 2.- RCS insertion at pericynthion after APS failure.



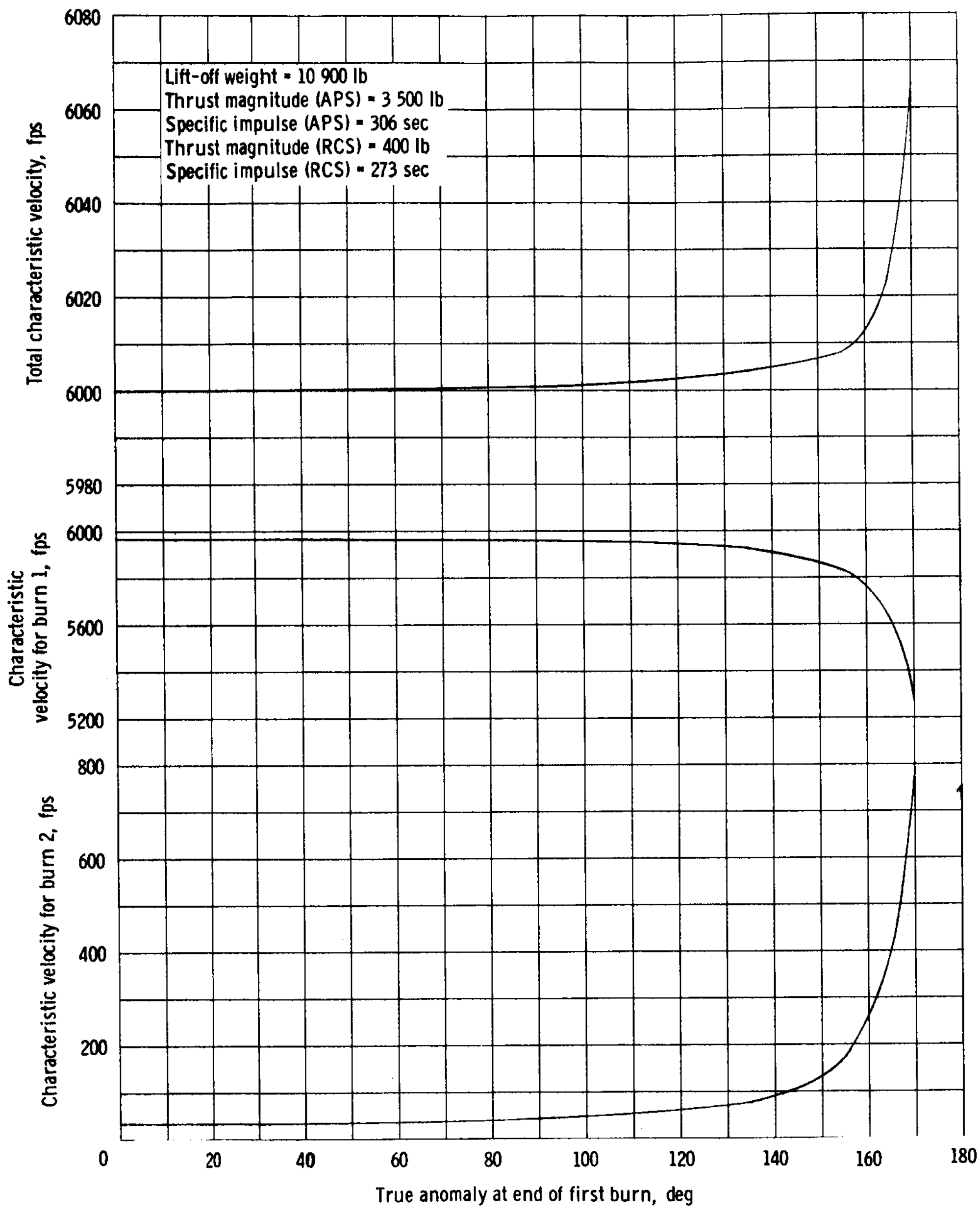
(a) Burnout altitude of Burn 1 = 4.94 n. mi.

Figure 3.- Velocity component requirements for a two-burn insertion at pericynthion into a 60 000-foot by 30-nautical mile orbit.



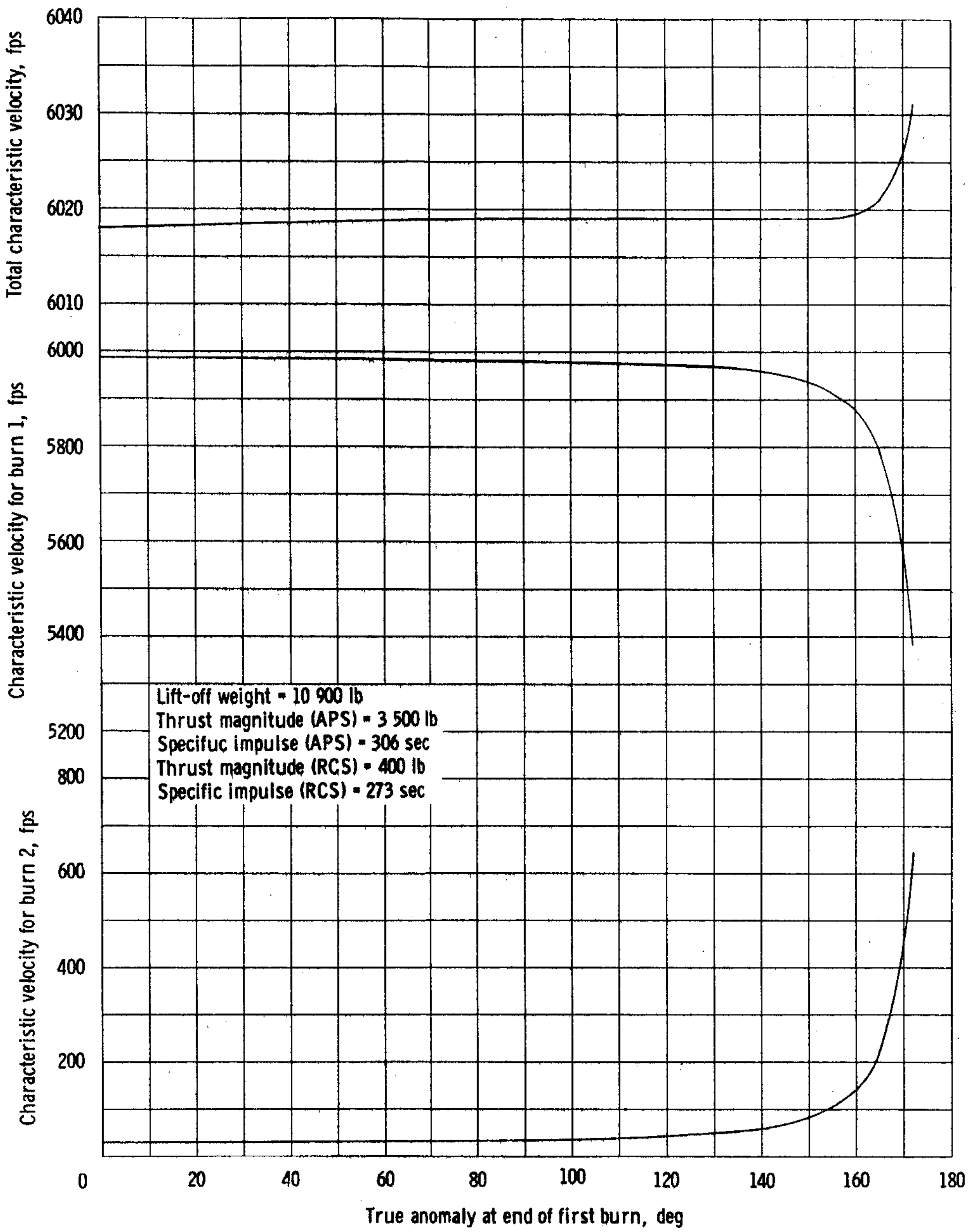
(b) Burnout altitude of Burn 1 = 7.4 n. mi.

Figure 3.- Concluded.



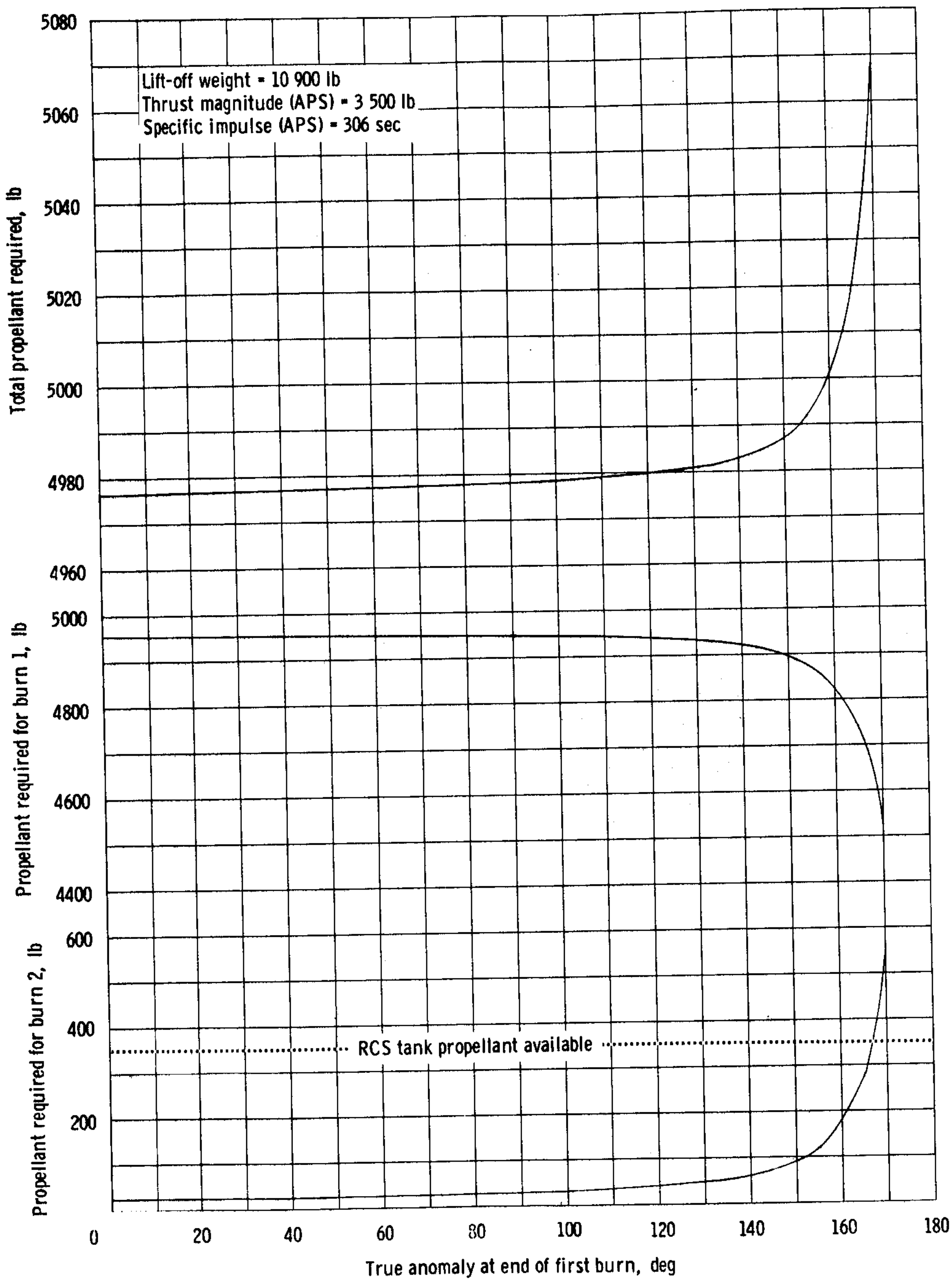
(a) Burnout altitude of Burn 1 = 4.94 n. mi.

Figure 4. - Characteristic velocity requirements for a two-burn insertion at pericynthion into a 60 000-foot by 30-nautical mile orbit.



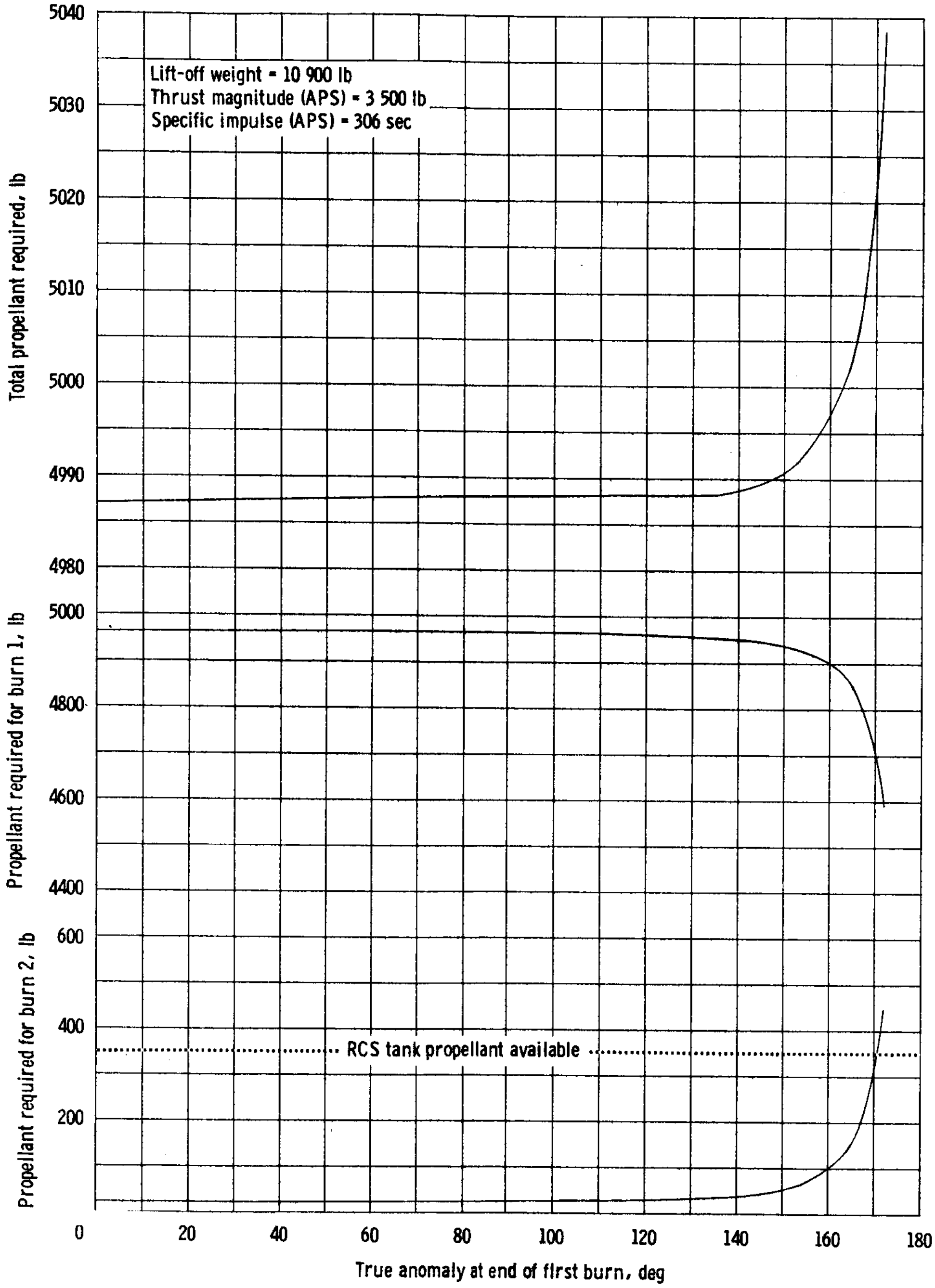
(b) Burnout altitude of Burn 1 = 7.4 n. mi.

Figure 4. - Concluded.



(a) Burnout altitude of Burn 1 = 4.94 n. mi.

Figure 5. - Propellant requirements for a two-burn insertion at pericynthion into a 60 000-foot by 30-nautical mile orbit.



(b) Burnout altitude of Burn 1 = 7.4 n. mi.

Figure 5.- Concluded.

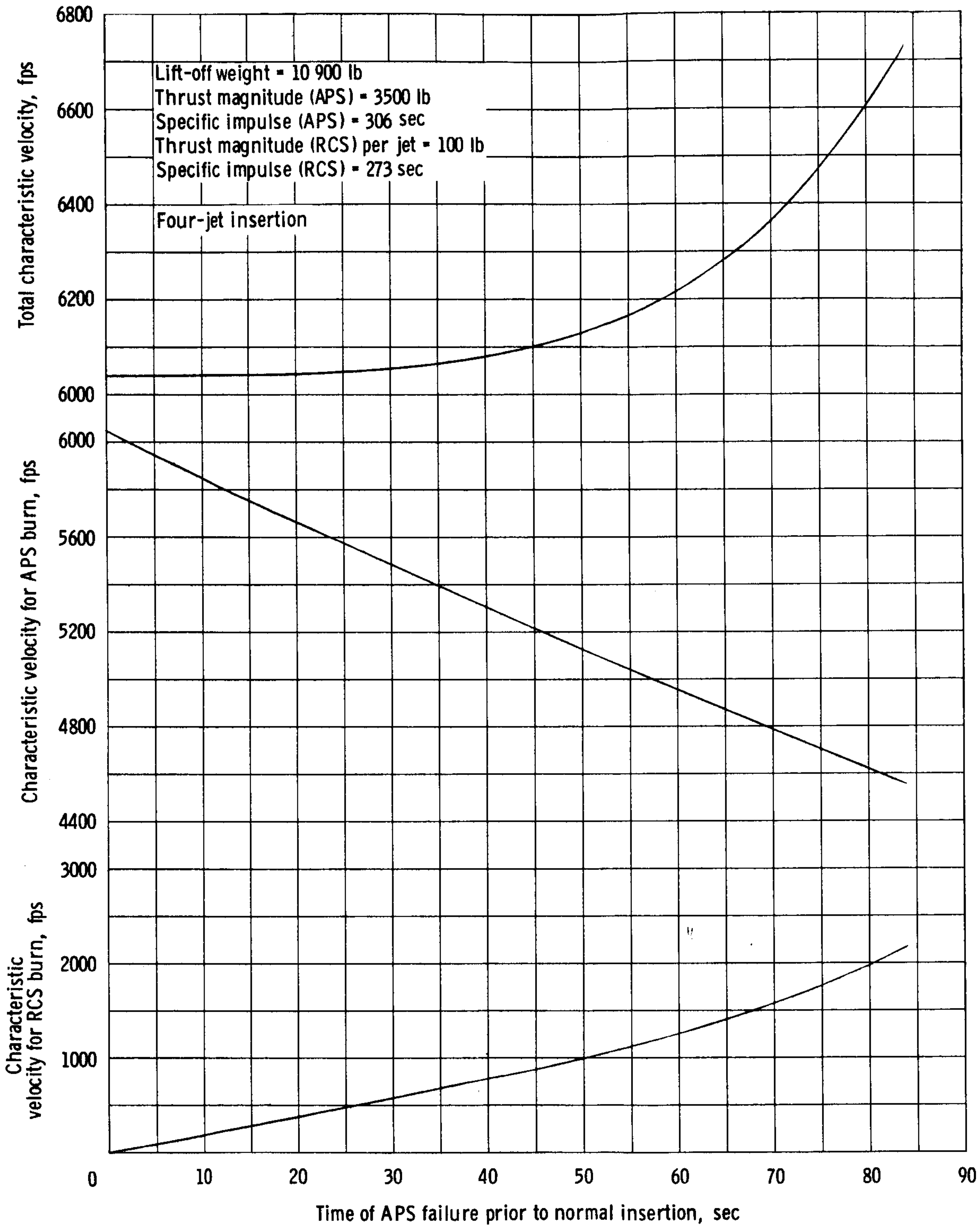


Figure 6. - Characteristic velocity requirements for an RCS insertion at pericynthion after APS failure.

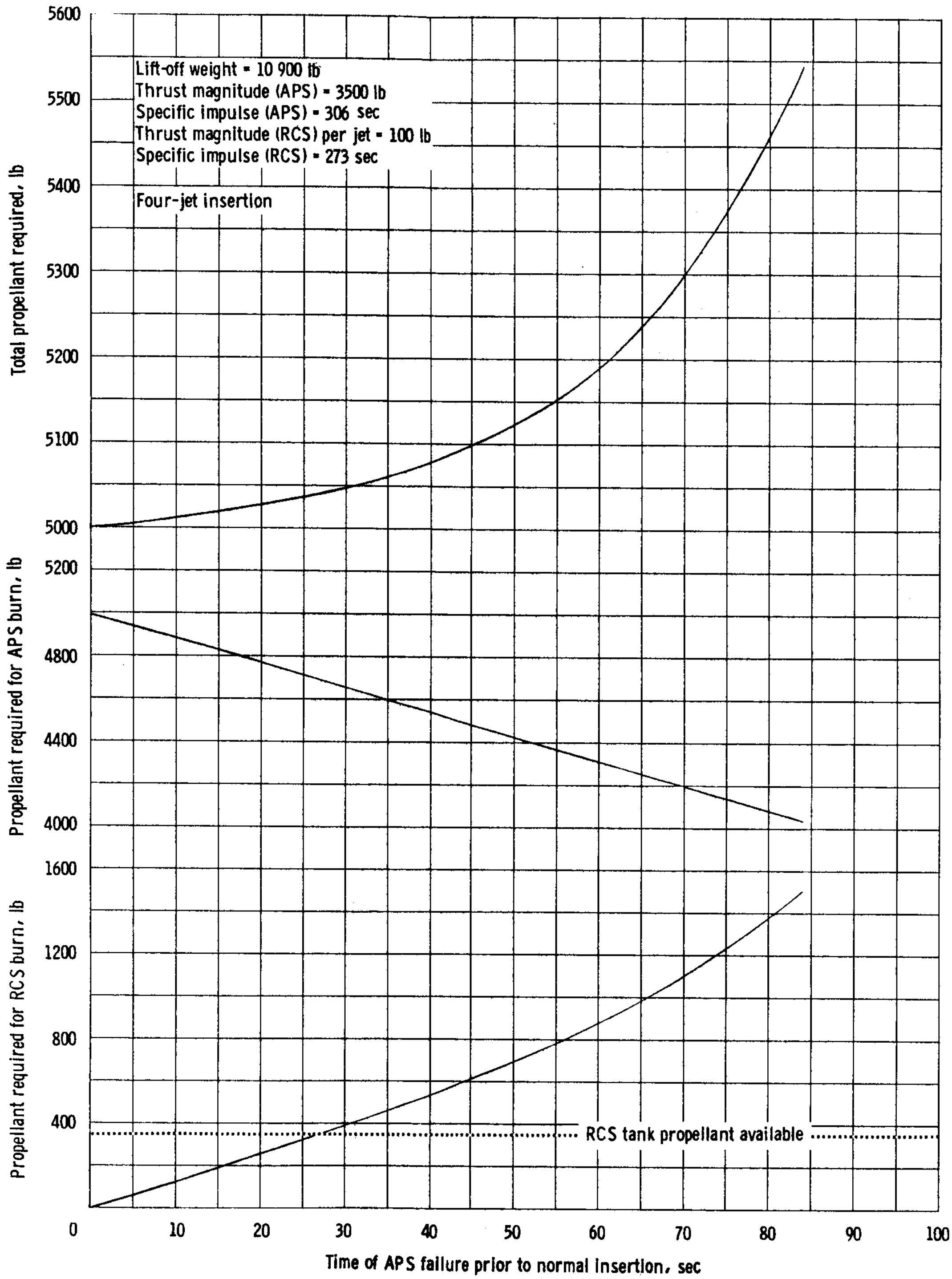


Figure 7. - Propellant requirements for an RCS insertion at pericynthion after APS failure.

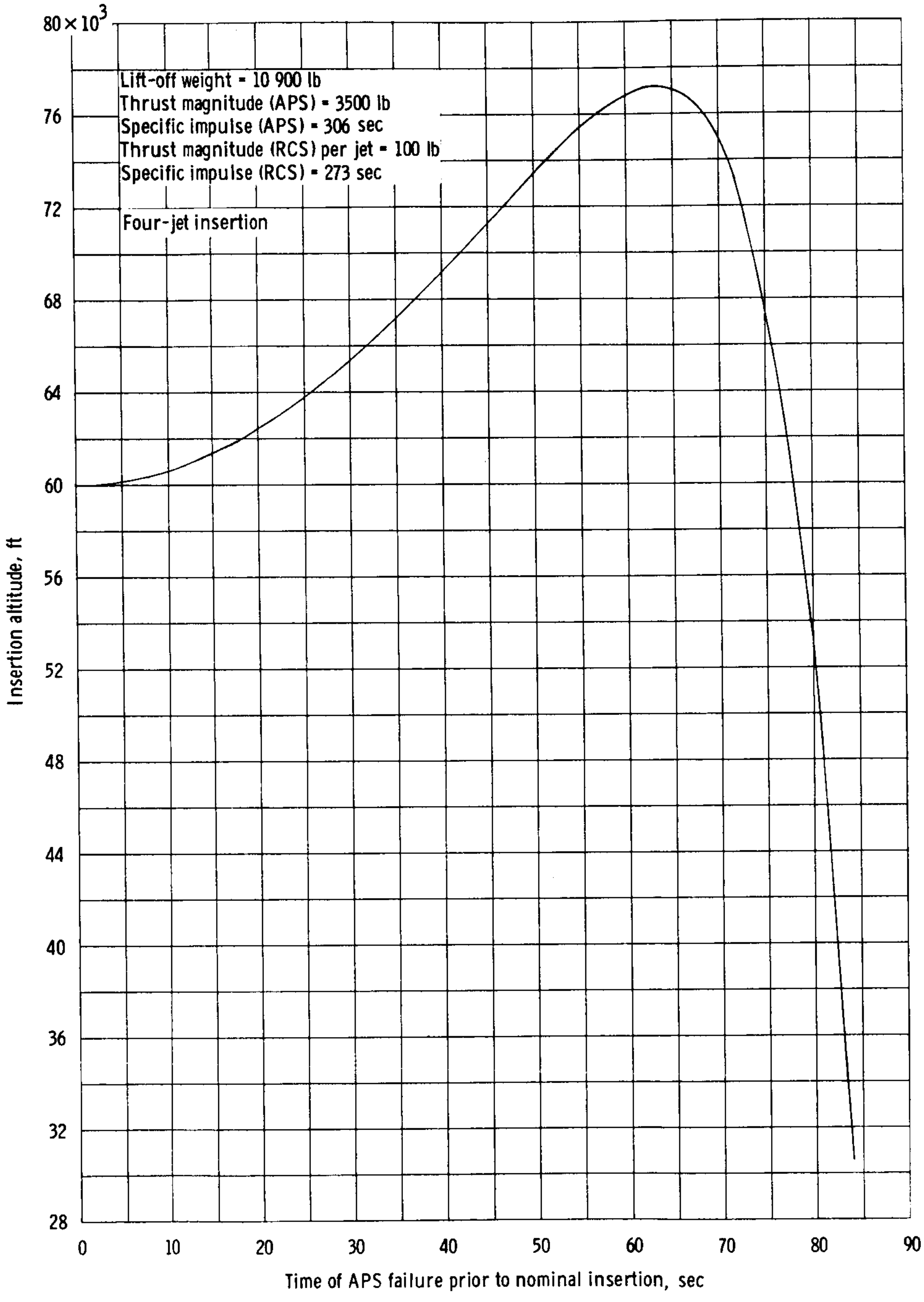


Figure 8. - Insertion altitude profile for an RCS insertion at pericynthion after APS failure.

REFERENCES

1. Payne, Joe D.: Comparison of LM PGNCS and AGS Orbit Insertion Guidance Logic and Procedures. MSC IN 68-FM-73, March 22, 1968.

2. System Operations Branch: CSM/LM Spacecraft Operational Data Book. Volume III, March 1968.